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DEPARTMENT OF COMMERCE

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INFORMATION CIRCULAR

METHOD AND COST OF MINING THE THICK FREEPORT COAL IN A WESTERN PENNSYLVANIA MINE

BY

J. W. PAUL AND H. TOMLINSON

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METHOD AND COST OF MINING THE THICK FREEPORT COAL IN A WESTERN PENNSYLVANIA MINE [1]

By J. W. Paul[2] and H. Tomlinson[3]

This report is one of a series of papers on coal mining methods and costs which are being prepared through the sponsorship of the U. S. Bureau of Mines for the purpose of bringing to the industry a knowledge of methods as they are used at the present time, and data on certain features which govern costs, safety, and conservation.

The methods employed are influenced by local conditions with respect to the character and dip of the coal, the nature of the roof and the thickness of the overburden, and the means employed for roof support and its control.

Mining costs are governed by the relative efficiency in applying the methods employed underground as well as by the selection of the method best adaptable to the physical conditions encountered.

This paper presents a detailed description of the methods used and the results obtained in the operation of a mine in the Thick Freeport coal bed in western Pennsylvania classed as a captive mine; the product of this mine is consumed by the parent company which is engaged in furnishing electric power, commonly known as a public service utility.

ACKNOWLEDGMENTS

Through the courtesy of the general superintendent and the cooperation of the operating staff of the mine in question, the details given herein have been made possible. This paper is printed with the approval of the executive official, who has checked the accuracy of the methods and data given.

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1 - The Bureau of Mines will welcome reprinting of this article, but requests that the following footnote acknowledgment be made: "Printed by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.)"
2 - Senior mining engineer, U. S. Bureau of Mines.
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HISTORY

This mine was opened in 1920, since which date 3,333,000 tons of coal have been produced up to and including 1928. The Thick Freeport coal in the district in which this mine is located has been developed by other mines on properties adjoining, one of the earliest of which was opened in 1901. Therefore, the quality and character of the coal had been established prior to the development of the mine under discussion.

GEOLOGY AND TOPOGRAPHY

The rocks of Allegheny County are embraced in the Washington, Monongahela, Conemaugh, and Allegheny groups of the Carboniferous Age. The Allegheny, of which the Thick Freeport coal bed is the top member, is the lowest of these groups and has a limited outcrop on the Allegheny River north of Pittsburgh. The measures are composed of massive sandstones, shale, thin limestones, and several beds of coal and clay. Since these measures are below the Thick Freeport coal, they are of no special importance in relation to development of this coal. The Conemaugh group above the coal consists of grey, red, and greenish shales, sandstones, limestones, and a number of coal beds, some of which are workable in other districts.

The immediate member of this group over the coal is the Mahoning sandstone which is coarse grained and hard, ranging up to 40 feet thick; the breaking of this member is one of the problems in the withdrawal of pillars. A generalized section of the measures above the coal is shown in Figure 1. This, however, does not include all the measures, which have a total thickness of 750 feet and which include a part of the Monongahela group, extending 30 to 80 feet above the Pittsburgh coal.

Between the Mahoning sandstone and the coal is a series of shale, bone, and carbonaceous shale forming the immediate roof, and it is this material that requires timber support in the advance mining work. At intervals, but without any regularity, this immediate roof material disappears, and the sandstone is found resting on the coal; in places the sandstone replaces a part of the coal bed, which adds to the expense of development, and where the coal is too thin for economic mining, the leaving of areas of thin coal adds to the difficulty of bringing-on roof subsidence in the pillar work. The replacement of the coal by the sandstone, forming what is known as "want" areas. is a notable characteristic in mines developed in the Thick Freeport coal.

A detailed section of the coal, immediate roof, and floor is shown in Figure 2. Figure 3 shows a washout.

Faults, dip.- There are no true displacement faults in the coal, and the dip averages 1 per cent, with occasional pitches of 6 per cent for short distances and a return to the original gradient.

Floor.- The immediate floor under the coal bed is a fire clay which ranges from 4 to 10 feet in thickness and which heaves very slightly along the line of pillar extraction. In the solid work no heaving action has taken effect.

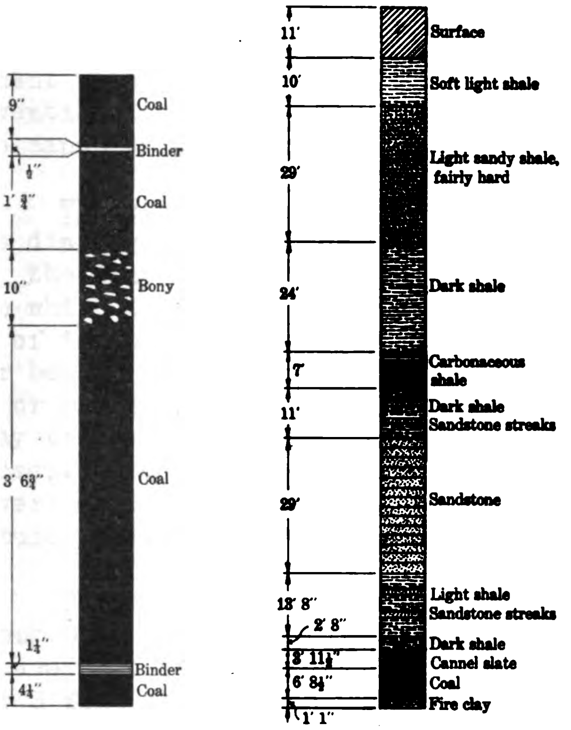

FIGURE 1. - LOG OF BOREHOLE AND SECTION OF THE COAL BED AS RECORDED FROM THE LOG

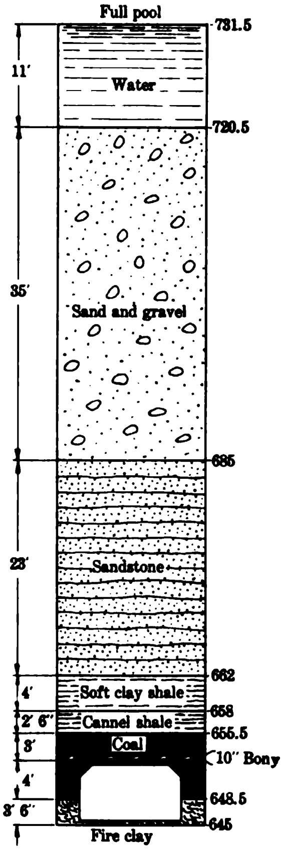

FIGURE 4. - TYPICAL CROSS SECTION OF ONE OF THE TUNNELS AND THE ROOF UNDER THE RIVER

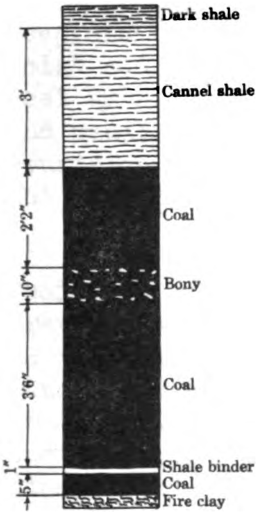

FIGURE 2. - AVERAGE SECTION OF THE COAL BED AND IMMEDIATE ROOF

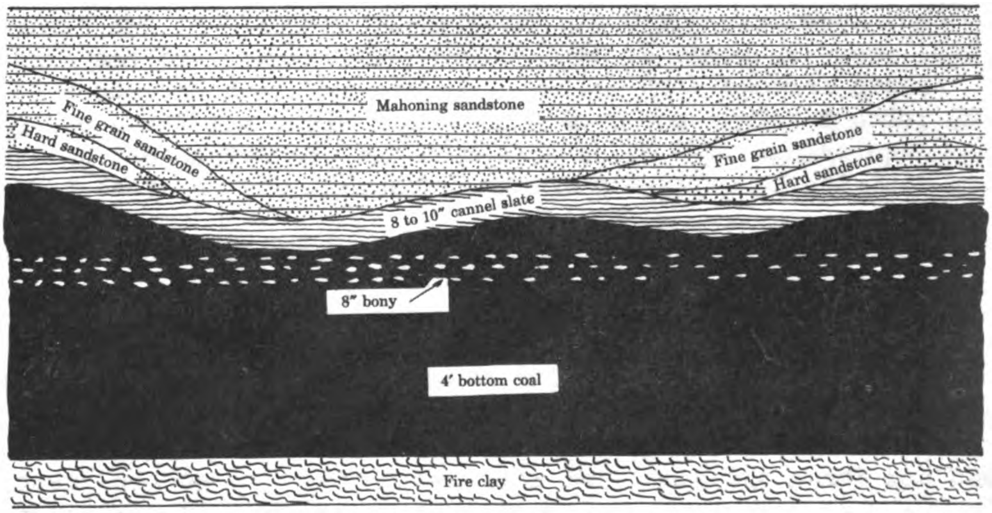

FIGURE 3. - A WASHOUT OF THE UPPER BENCH OF THE COAL, LOCALLY TERMED A "WANT"

Water.- Very little water is encountered in the solid or pillar workings, and such as is present has an alkali reaction. The greater quantity of water, amounting to 350 gallons per minute, comes from the vicinity of the shaft and from a gravel bed overlying the entries near the shaft.

In mines in the same coal bed within a radius of 5 miles, previously developed, there has not been any indication of gas pressure within the coal or adjacent strata, although in unventilated parts gas has accumulated; therefore, the ventilation of this mine presented no unusual problem, except to provide ample capacity and means for conducting the air under low pressure.

The coal bed.- The coal bed, which averages 7 feet in thickness, has three distinguishing benches - the lower, which is persistent and averages 4 feet, the bony which lies near the middle and is persistent, and the upper bench which is about 2 feet 2 inches but varies in thickness; where the thickness of the bed becomes less than normal it is always at the expense of the upper bench. In the "want" areas it is the upper bench that is lacking in its full or partial development. The character and quality of the coal is such that it may be used for by-product coking, steam, and for domestic and gas-making purposes. However, the entire product of the mine is used for steam generation. An average proximate analysis of the upper and lower benches is as follows: Moisture, 2.4; volatile matter, 34.5; fixed carbon, 55.0; ash, 8.1.

The coal has an inch shale band about 5 inches from the bottom and a bed of bony 8 to 10 inches thick about 4 feet from the bottom. Above the bony the coal averages about 2 feet 2 inches. Immediately above this is a cannel shale about 3 feet thick which forms the immediate roof. The bony near the middle of the bed is relatively high in combustible material and gives about 10,000 B.t.u., but it is discarded, although when pulverized and mixed with coal in similar form it would prove to be a source of power.

SHAFTS AND TUNNELS

Shafts.- Access to the mine is by means of a hoisting shaft 162 feet deep and by an air shaft and double deck slope which are 3,300 feet from the hoist shaft. The shaft has two compartments and is oval in cross section, 16 feet by 20 feet. The sandstone over the coal is overlain with glacial drift and sand; in sinking the shaft the Moran type of air lock was employed under 25 pounds' pressure down to the sandstone, but from this point the regular open cut method was employed to reach the coal which has an elevation of 642 feet A.T.

The slope is dipping 33-1/3 per cent, and the lower compartment is 12 feet wide by 12 feet high, 542 feet long; it is used as an intake airway and is provided with a track for the transport of materials. The upper compartment is 12 feet wide and 7 feet high and is used as a manway; it is equipped with a continuous concrete stairway and in it are placed the electric power lines well protected. This upper compartment connects at its bottom with the manway entry. The air shaft is approximately 300 feet south from the slope, 15 feet in diameter, 164 feet deep, and is concrete lined. The main hoisting shaft has one compartment in which tandem skips operate in balance; this shaft has also a second compartment equipped with a winding concrete stairway and having space for pipes at either side.

Tunnel construction.- The coal acreage under development is on the opposite side of a river from the hoisting shaft and preparation plant and lies 80 feet below the bottom of the river; to connect the mine with the hoisting shaft two parallel tunnels were driven in the coal under the river. The overlying sandstone is 28 feet thick and forms the main roof over the tunnels, as shown in Figures 4 and 5. These tunnels are 10-1/2 feet wide by 7 feet high and 1,400 feet long between shore lines of the river. Such water as was intercepted was controlled by grouting and some of the crevices required from 400 to 600 bags of cement before the water was shut off; 15 to 20 holes in the roof were required in some instances and an air pressure of 80 to 160 pounds was used. Sets of 10 by 10 inch square timber were installed in parts of the tunnels, the roof at most places being self-supporting.

The Hoist.- A balanced, tandem skip hoist is in service in the hoisting shaft. The headframe is of steel construction and the winding drum is operated by an electric motor. Each of the skips have two compartments, one above the other, and are loaded from single car capacity bins located below the two car rotary dump at the foot of the shaft, as illustrated in Figure 6.

The product of the mine when delivered to the top of the shaft is taken over by the parent company, and after being passed through a crushing plant is taken to the point of consumption nearby.

METHOD OF DEVELOPMENT AND MINING

(a) The general plan of development has been the regular entry room-and-pillar method laid out in panels, Figure 7. From the foot of the slope and air shaft seven parallel entries 11 feet wide and on 50-foot centers were driven in the coal. Four of these are used as air courses, two as haulages, and one as a manway. From these entries at intervals of 1,800 feet four face entries, 11 feet wide and on 50-foot centers, have been turned at right angles. Barrier pillars 200 feet wide have been left on either side of all main and face entries. From the face entries pairs of butt entries have been turned at intervals of 300 feet. These butt entries are driven to their limit, after which rooms 15 to 18 feet wide are driven from one entry on 90-foot centers. Figure 8 shows the plan of the development of five butt entries with the periodic break lines indicated extending across as many as five pairs of butt entries, and is an exhibition of successful panel-retreating method of mining.

When the rooms have advanced beyond the second crosscut a bisecting room is started in this crosscut which then places the rooms on 45-foot centers. The advancement of the rooms is so timed that the face of each lags behind the adjacent room by 52 feet; when the room has advanced its full distance, plus the distance through the chain pillar of the next butt entry, the face is then on the main break line which is on an angle of about 49° degrees with the butt entry, and the room pillar is ready to be brought back. See Figure 9. The break lines are about 1,800 feet long and extend across four pairs of butt entries.

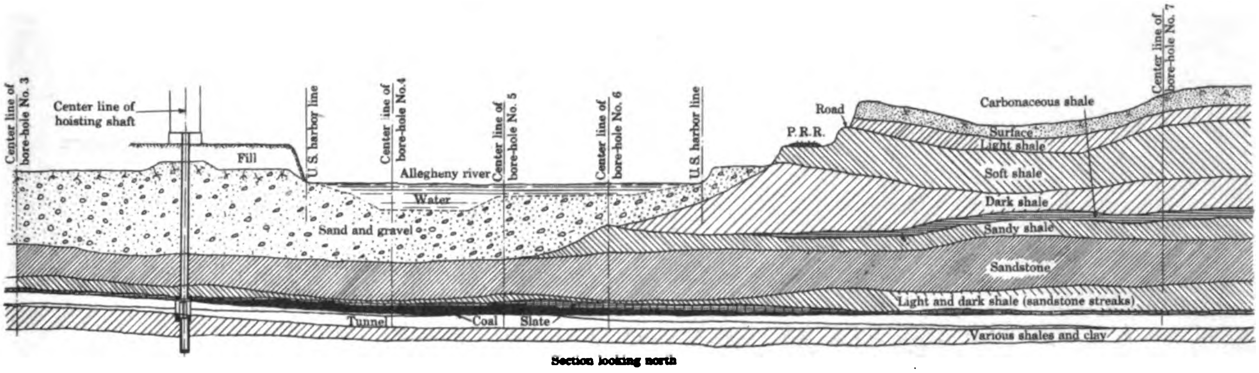
Center line of bore-hole No. 3
Center line of hoisting shaft
Fill
U.S. harbor line
Center line of bore-hole No. 4
Allegheny river
Center line of bore-hole No. 5
Water
Center line of bore-hole No. 6
U.S. harbor line
Sand and gravel
P.R.R.
Road
Carbonaceous shale
Surface
Light shale
Soft shale
Dark shale
Sandy shale
Center line of bore-hole No. 7
Sandstone
Light and dark shale (sandstone streaks)
Tunnel
Coal
Slate
Various shales and clay
Section looking north

FIGURE 5. - PROFILE SHOWING STRATA ABOVE THE RIVER TUNNELS

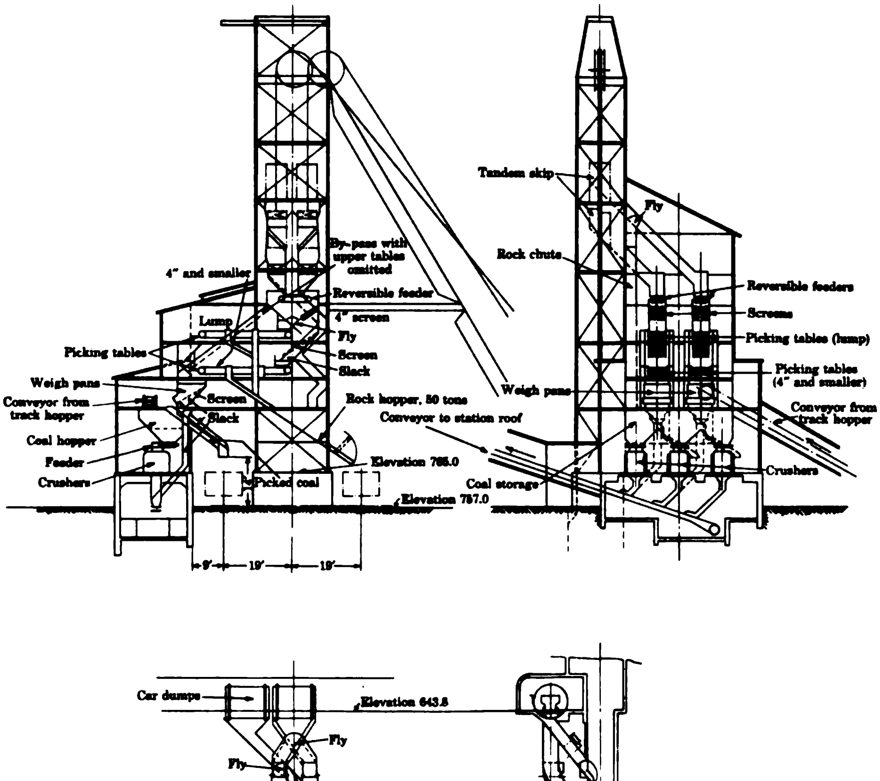

FIGURE 6. - HEADFRAME AND TIPPLE AT SURFACE AND DUMP. AND SKIP LOADING AT SHAFT BOTTOM

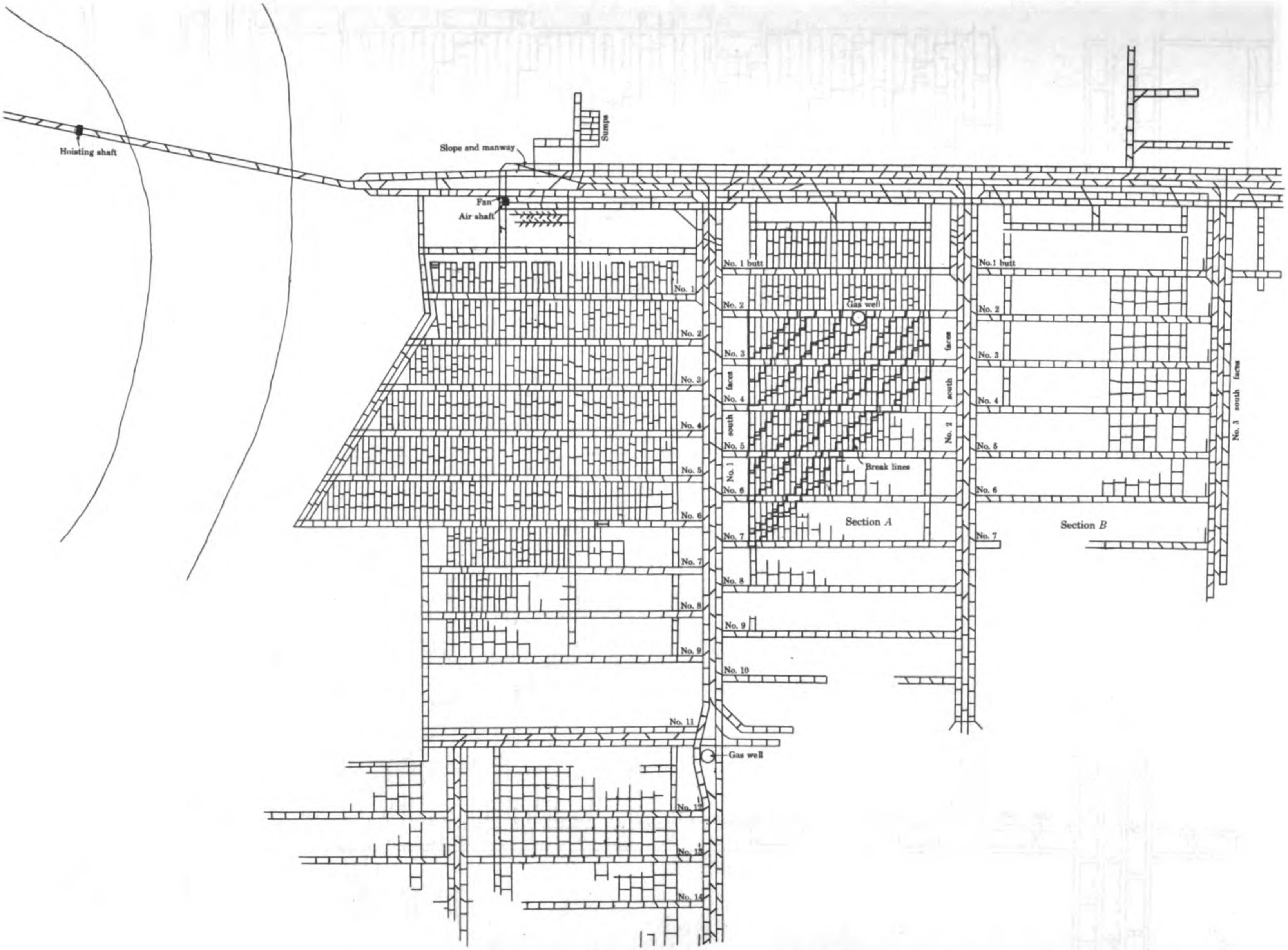

FIGURE 7. - PLAN OF THE MINE DEVELOPMENT. SECTION A AND B SHOWN IN FIGURES 8 AND 9, RESPECTIVELY

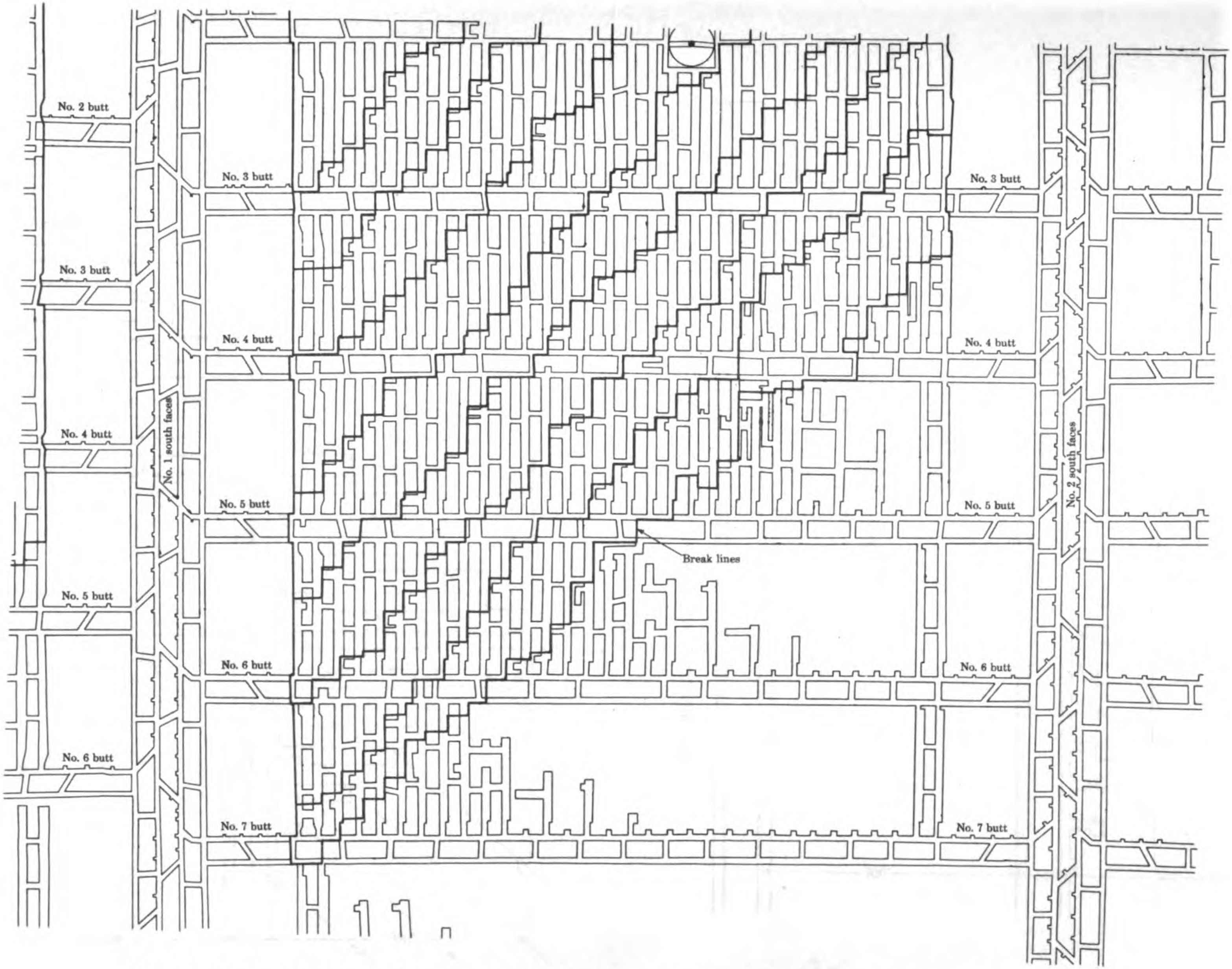

FIGURE 8. - PLAN OF SECTION A OF FIGURE 7, SHOWING WORKED-OUT PANELS AND POSITION OF THE BREAK LINE CROSSING FOUR PAIRS OF BUTT ENTRIES

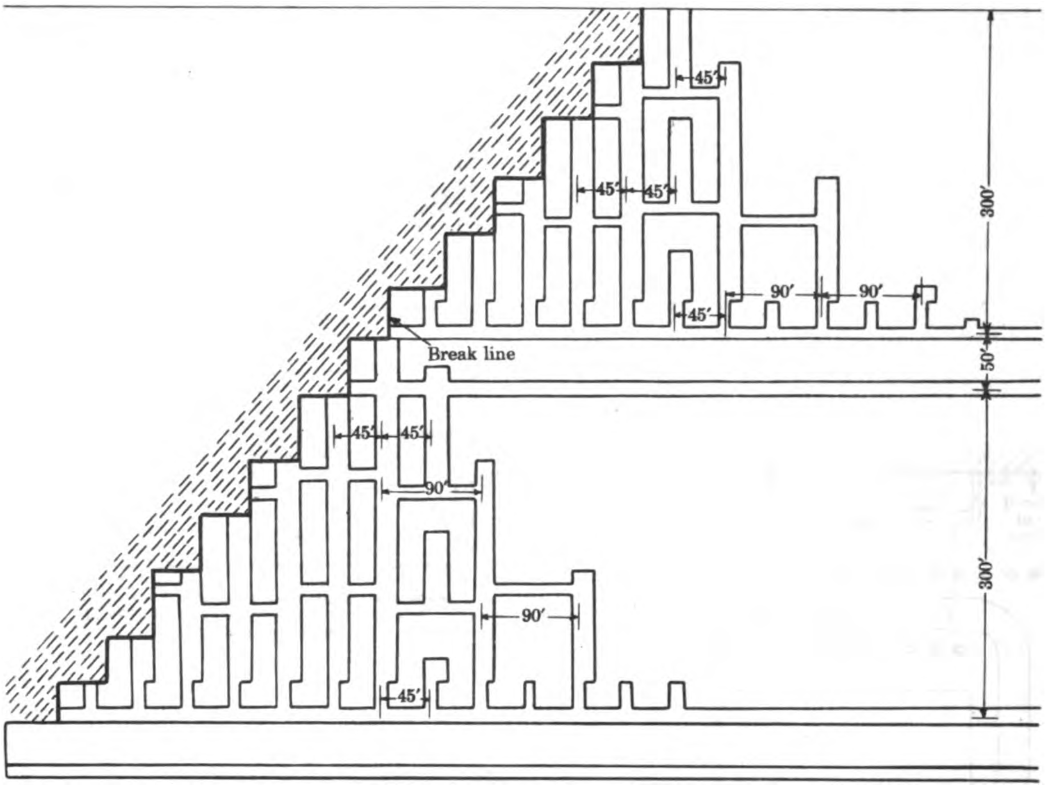

FIGURE 9. - METHOD OF TURNING ROOMS ON 90-FOOT CENTERS

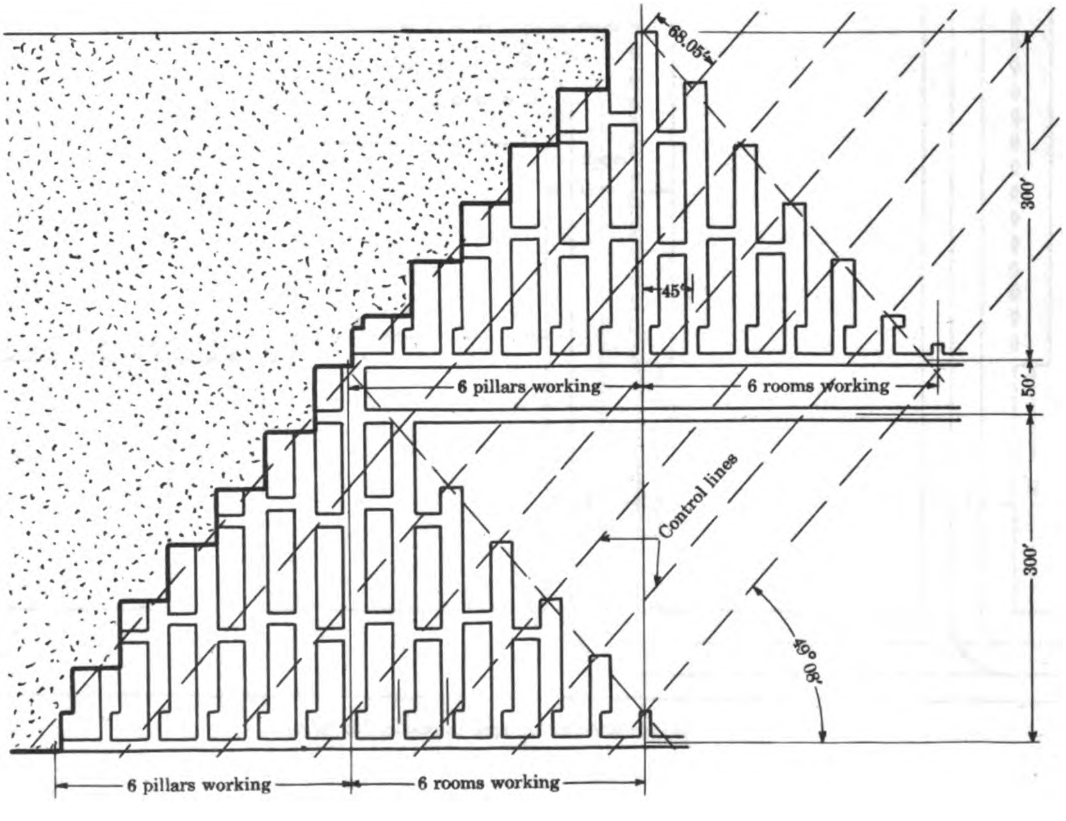

FIGURE 10. - CONTROL LINES FOR PROGRESS OF ROOM ADVANCE AND PILLAR EXTRACTION

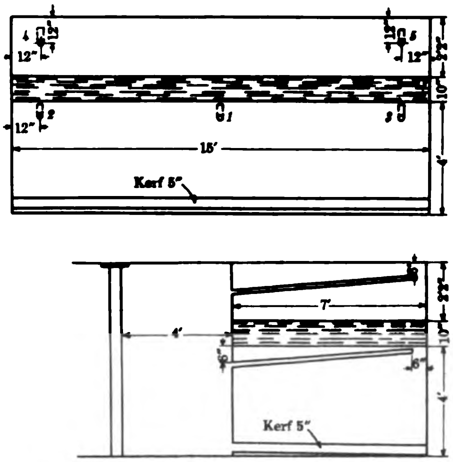

FIGURE 11. - POSITION OF SHOT HOLES IN A ROOM 15 FEET WIDE. FIGURES IN CIRCLE INDICATE SEQUENCE OF FIRING

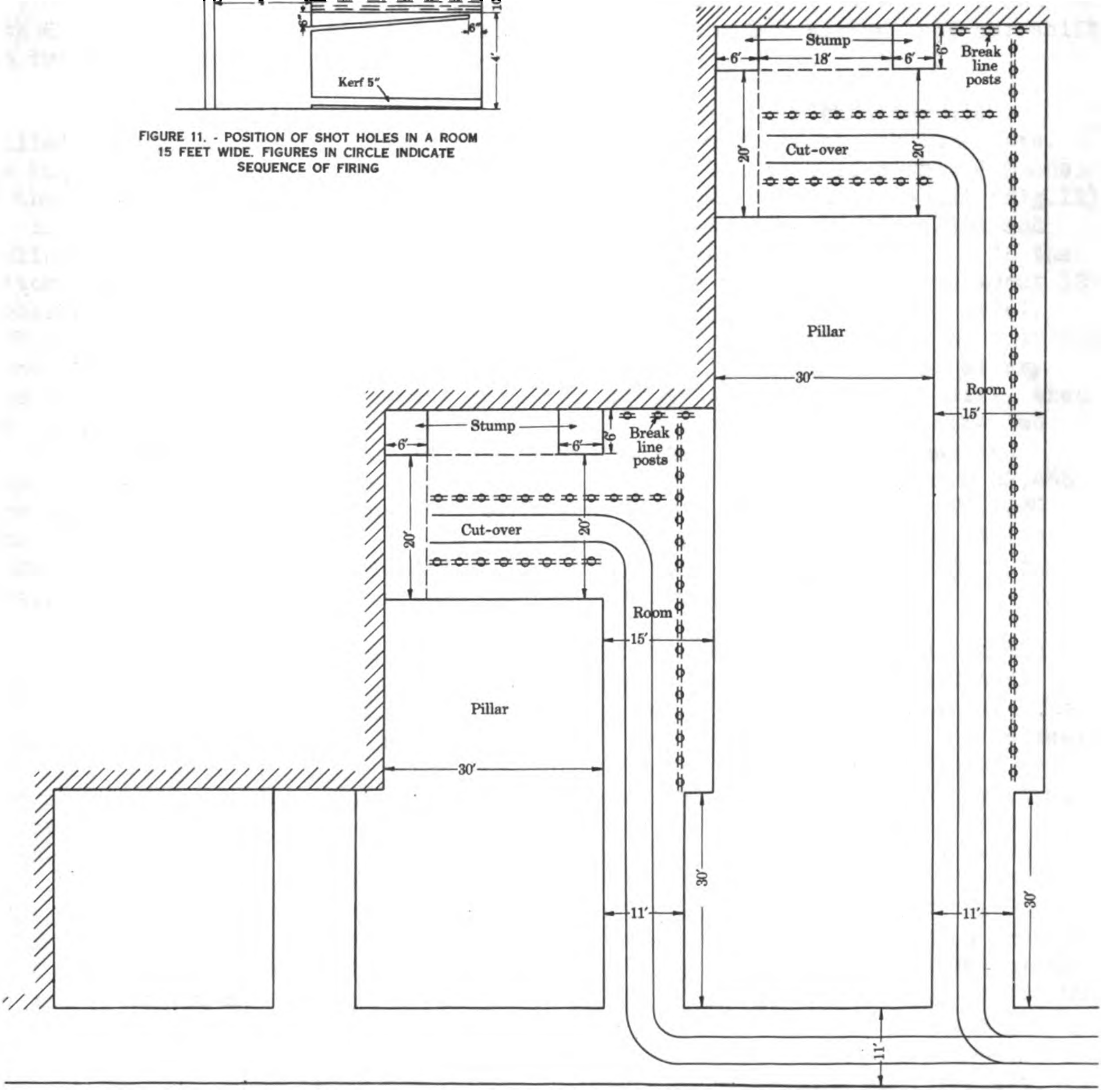

FIGURE 12. - METHOD OF RECOVERING ROOM PILLARS

Control lines are placed on the working map for the guidance of the supervising officials (fig. 10). The distance between the control lines is determined by a line passing through the face of each succeeding room so that the faces will always be 52 feet apart. Strict adherence to the engineering aspects of this scheme is responsible for a recovery of 95 per cent of the coal, a break line under control, and a minimum disturbance of the immediate roof back of the break line, all of which have contributed to an excellent accident record.

(b) (1) Mining. All the coal is mined by electrically driven machines of the shortwall type, ten of which are equipped with 7 feet cutter bars and two with 6 feet bars. These machines average undercutting 240 to 250 tons per shift, and two men are required to operate each machine.

(2) Drilling and blasting. The shot holes for blasting are drilled with post augers by the miner and this is a part of his tonnage rate. The auger is 1-3/4 inches in diameter and the holes are drilled within 6 inches of the depth of the undercut. Five holes are employed for each new cut (fig.11), two in the top about 12 inches from the roof and 12 inches from the ribs and inclined so the back of the hole will be 5 to 6 inches below the roof. In the bottom coal, three shots are employed just below the band of bony, one about 12 inches from each rib and one in the center, and the holes are drilled level. Each shot is charged with two sticks of permissible explosive (1-1/8 by 8 inches), tamped to the collar with clay, and fired electrically by a shotfirer at any time during the shift. The center shot in the bottom coal is fired first, then the two bottom rib shots, and after the bottom coal has been loaded, the two top shots are fired. The bony is separated from the coal by the miner and temporarily stored for future disposal. In a recent month during which 52,458 tons were produced, 9,831 pounds of explosive were used, an average of 5.336 tons per pound of explosive. Since all the product of this mine is used for stoker feed boilers and pulverized combustion, there is no special object in obtaining prepared sizes other than for cleaning purposes.

(3) Rooms and pillars. Rooms are developed by advancing on the face cleats of the coal; in withdrawing pillars, cuts are made through the pillar on the butt cleats which are not so pronounced as the face cleats. The cuts made in the room pillar are 20 feet wide, leaving a curtain of coal 6 feet wide near the gob (fig. 12). This curtain, being as long as the width of the room pillar, is withdrawn by cutting out a space in its center leaving a stump 6 feet or less square at each end. These stumps are either recovered by pick mining or are blasted out in order to leave no roof support, in which latter case the coal is lost. Figure 12 gives the details of the sequence of the operation. When two of these cuts have been taken out, the props are withdrawn back to the breaker line of props and the roof caves to this line, leaving a triangular space, the base of which is 45 feet and altitude of 52 feet measured along the rib of the room. The hypothenuse of this triangle makes an angle of $49^\circ 08'$ with the line of the butt entry, as shown in Figure 10. By using this angle along a line to intersect the center of the faces of the rooms, the room faces are kept 52 feet ahead or in the rear of the adjoining rooms. By intersecting the pillar control line with the room control line on the center of the face of

any one room, the next control line will be where it crosses the center of the face of the next room and 52 feet ahead or behind it. The distance between these succeeding control lines in this case works out to be 68.05 feet.

As in all efficiently operated mines, the development entries are kept well ahead of the panel mining. In narrow work no yardage is paid as such, but an additional price per ton is paid the miner and the cutters over the scale paid in wide work, such as rooms.

(4) Loading. All loading of coal and refuse is done by hand. The refuse consists of the bony partingin the coal and is separated by the miner. In narrow places it is loaded and sent to the shaft for disposal. In the room-and-pillars work, the bony is stored in the mine as gob material. At the surface plant the product is sized and hand picked.

(5) Deadwork. In addition to loading coal, the miner must do other work which is covered in the compensation for drilling, charging, loading and cleaning coal, as is the general practice in American coal mines. This involves care of the roof and its support in his working place, the laying of track in rooms and of temporary track in entries. All fallen material that obstructs operations is removed by special daymen. The bony in the coal is gobbed by the miner in the rooms and loaded into cars in entries.

A certain amount of exploration work is necessary when a washed-out area locally called a "faulted" area is encountered. This is where the upper bench of the coal has disappeared, leaving the bony and lower bench in its normal development. The cannel slate decreases in thickness from 3 feet down to 8 or 10 inches; on top of this and immediately under the Mahoning sandstone appears a bed of fine-grained sandstone, very hard, 2 to 3 feet thick, and locally termed "cement stone." A section of the mine under exploration at the time of this presentation covered a face entry with six pairs of butt entries and furnished the largest item of expense under deadwork, labor and material, amounting to 1.463 per cent of the total cost of production.

(6) Timbering. As the immediate roof; a cannel shale varying from 3 to 4 feet in thickness and having few slip planes, affords an exceptionally good roof, artificial supports for this along the entries and haulageways are necessary only at intersections of entries or in wide places and at places where the upper bench of coal is absent. Such supports as are used consist of 6 or 12 inch steel I-beams supported by hitches cut in the ribs of the entries and overlaid with 5 by 6 inch timber lagging; also, at intersections concrete pillars are used. (see fig. 13.)

A definite system of roof support has been adopted for the room-and-pillar work. In rooms 15 feet wide, a row of posts with cap pieces is placed 10-1/2 feet from the rib on the track side, spaced on 3 feet centers and installed within 6 feet of the face of the room before the coal is blasted (fig. 14). A safety post is used under the bony parting while the bottom coal is being loaded, Figure 15. Where crossbars are needed in rooms or advancing entries, 40 to 60 pound T-rails are used. Wooden crossbars are being gradually discarded. In the cutovers in pillar work a row of posts is placed on either

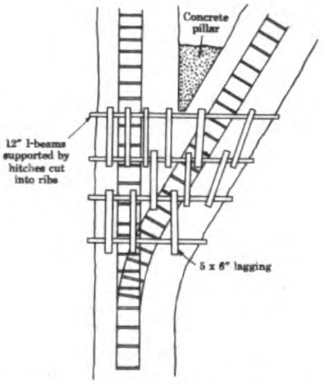

FIGURE 13. - PLAN OF METHOD OF ROOF SUPPORT AT INTERSECTION OF ENTRIES

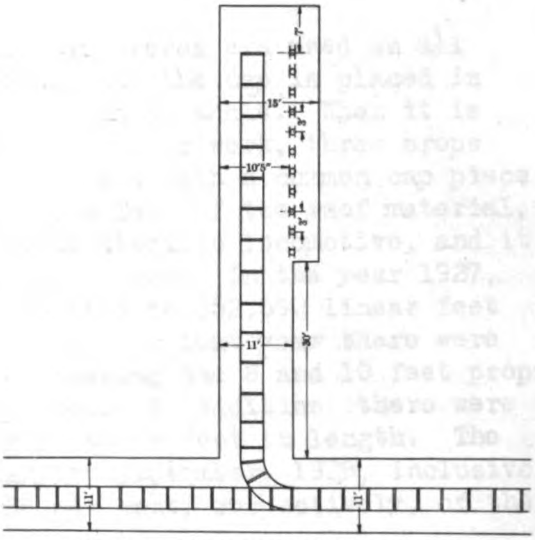

FIGURE 14. - POSITION OF POSTS IN ROOM 15 FEET WIDE BEFORE THE COAL IS UNDERCUT

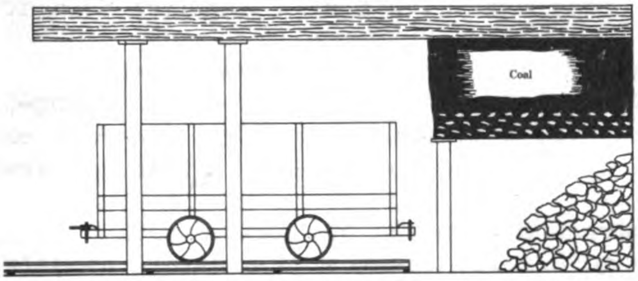

FIGURE 15 - POSITION OF SAFETY POST WHILE THE BOTTOM COAL IS BEING LOADED

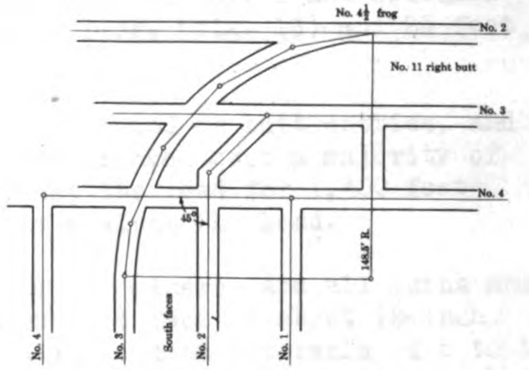

FIGURE 16. - DETAILS OF CURVE LEADING FROM A BUTT TO A FACE ENTRY

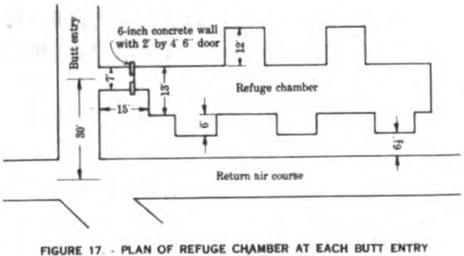

FIGURE 17. - PLAN OF REFUGE CHAMBER AT EACH BUTT ENTRY IN NEW DEVELOPMENT WORK

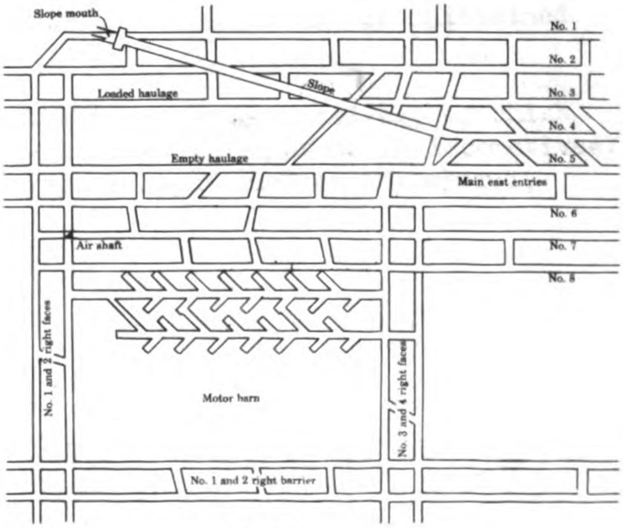

FIGURE 18. - PLAN OF MOTOR BARN

side of the track and on 3-foot centers. While cap pieces are used on all posts, there is no uniformity in their dimensions, and the cap is placed in any direction owing to the uniform texture of the cannel shale. When it is desired to make a fall of the roof material in the pillar work, three props with cap pieces are set in a row, sometimes five posts with a common cap piece 6 by 6 inches are used (fig. 12). To bring about a fall of the roof material, the posts are withdrawn by means of a cable and an electric locomotive, and it is estimated that 30 per cent of the posts are recovered. In the year 1927, the quantity of timber used for roof support amounted to 352,390 linear feet and based upon a production of 622,242 tons of coal for that year there were 1,765 tons per linear foot of timber used. Considering the 8 and 10 feet props alone, there were 14.74 tons produced per prop used. In addition, there were used 963 crossbars 6 by 6 inches, varying from 10 to 14 feet in length. The cost data available on timber used from February to September, 1928, inclusive, show labor and material costs of .734 and 1.083 per cent, respectively, of the total cost of production.

Haulage.- Mine tracks and hauling equipment have been standardized. A track gauge of 44 inches is used. The standard radii of curves and switches are 148.5 feet for main haulage with a No. 4-1/2 frog, (fig. 16) and 25 feet for room turnouts with a No. 1-3/4 frog.

Rails are 60-pound on main haulageways, 40-pound on butt entries, and 30-pound in rooms. The main haulageway is double-tracked over a majority of the distance and has a grade of 2 per cent against the load for 1,400 feet near the shaft; the rest of the haul is slightly against the load.

Room tracks are placed and maintained by the miners, and all turns and switches are laid by daymen. Ties 6 by 6 inches by 6 feet on about 18-inch centers are used under 60 and 40 pound steel rails, and at intervals of 5 to 10 feet steel ties are placed. These main-line tracks are ballasted with crushed slate and sandstone. Steel ties are used under 30-pound rails in rooms and temporary track in entries, spaced about 3 feet apart. Permanent track in entries is maintained not less than 200 feet from the face. In all places in the mine a minimum clearance of 4 feet from the side of the car is maintained on one side.

The cars are delivered to and from the faces by locomotives, of which there are eight storage-battery, and four 8-ton reel-type gathering locomotives. The following table shows an average day's work as performed on November 1, 1928:

Average day's work performed by locomotives

Type of locomotive	Shift	No. of cars coal	No. of cars refuse	District operating
Reel	Night	66	4	1st south mains.
Reel	Day	80	2	1st south mains.
Reel	Night	56	9	0 south mains.
Storage battery	Day	57	2	No. 6 butt, 1st south mains.
Storage battery	Day	61	-	No. 7 butt, 1st south mains.
Storage battery	Day	73	-	No. 7 butt, 1st south mains.
Storage battery	Day	69	1	No. 9 butt, 1st south mains.
Reel	Day	81	3	0 south mains.
Reel	Day	72	3	No. 12 and 14 butts, 1st south mains.
Storage battery	Day	54	1	No. 2 south mains.
Reel	Day	91	3	No. 3 south mains.
Reel	Night	62	4	No. 3 south mains.
Total		822	32	

The average number of cars gathered per gathering locomotive on this average day was 71.17. The average number of cars gathered per reel locomotive was 76.57. The average number of cars gathered per storage-battery locomotive was 63.6.

The above table shows that 854 cars were delivered to and from the faces on this average day, 822 of which were coal and 32 were refuse such as bony or cannel shale. On being gathered from the faces the loaded cars are deposited at or near No. 1 room on the butt entries off No. 1 south faces, where they are picked up by the flatroad motor. The average length of haul for the gathering locomotives is from 500 to 1,500 feet.

On the 1st south faces, a flat-road 15-ton locomotive hauls from near No. 1 room on the butt entries to a side track between No. 1 butt and the main east entries. This is the only secondary haulage in operation at this time. On No. 2 and No. 3 south main face entries, the gathering locomotives deliver to a side track between No. 1 butt and the main east entries, as in No. 1 south face entry.

From the side tracks to the shaft is the main-line haul on which three 15-ton Goodman locomotives are employed hauling 20 car trips. The following table gives the number of cars hauled by each locomotive on November 1, 1928, which would be an average day's operation:

Locomotive..........	No. 8	No. 11	No. 16	No. 17	Total
Loads to shaft......	83	339	350	279	1051
Empties from shaft..	20	583	59	287	949

The cars delivered to and from the main-haul side tracks were as follows:

1st South Face

Locomotive.....	No. 8	No. 11	No. 16	No. 17	Total
Loads..........	83	299	270	-	652
Empties........	20	560	59	39	678

2nd South Face

Locomotive.....	-	-	No. 16	No. 17	Total
Loads..........	-	-	40	120	160
Empties........	-	-	-	57	57

3rd South Face

Locomotive.....	-	No. 11	No. 16	No. 17	Total
Loads..........	-	40	40	159	279
Empties........	-	23	-	191	214

No. 8 locomotive makes only two trips to the shaft, one at the beginning and one at the end of the shift, and in the meantime operates on the flat-road haul of No. 1 south face entries. Nos. 11, 16, and 17 locomotives are the main-haul locomotives.

During this shift these locomotives hauled 968 loads to the shaft and 929 empties from the shaft, an average of 322.66 loads, or approximately 1,162 tons and 309.66 empties per main-line locomotive. Although the tables for the gathering locomotives show that 854 loads were gathered during this shift, and the main-haul tables show 1,050 loads taken to the shaft, this difference is due to the fact that the day preceding was an idle day and some cars had been loaded and held in storage to be taken to the shaft on the work day. The difference between the number of loads and empties is due to standing cars at the shaft.

Main haulage.- Table No. 1 has been compiled showing the ton-miles of work accomplished by main haulage locomotives on Nov. 1, 1928, which has been used as an average day for this study. The average weight of coal in the car for 1927, when 173,147 cars were dumped at the shaft with a total tonnage of 622,242, was 3.59 tons. The weight of the empty car is 3,970 pounds or 1.98 tons. The length of the main haul from the 1st south faces is 1.08 miles, and 652 loads and 678 empties were hauled, accomplishing 3,929 and 1,452 ton-miles of work, respectively, or a total of 5,381 ton-miles of work. The length of the main haul from the 2nd south faces is 1.48 miles. One hundred and sixty loads and 57 empties were hauled, accomplishing 1,321 and 167 ton-miles of work, respectively, or a total of 1,488 ton-miles of work.

The length of the main haul from the 3rd south faces is 1.84 miles; 239 loads and 214 empties were hauled, accomplishing 2,568 and 779 ton-miles of work, respectively, or a total of 3,347 ton-miles of work. This shows that a total of 1,051 loads were hauled to the shaft and 949 empties were hauled from the shaft, performing 10,216 ton-miles of work.

Table 1.- Details of ton-miles of electric locomotives on the main haulage, Nov. 1, 1928

(Average weight coal, 3.59 tons; weight of car, 1.98 tons)

	Locomotive 8					Locomotive 11					Locomotive 16					Locomotive 17					Total cars	Total ton-miles
	Cars	Ton-miles load	Ton-miles car	Ton-miles empty	Total ton-miles	Cars	Ton-miles load	Ton-miles car	Ton-miles empty	Total ton-miles	Cars	Ton-miles load	Ton-miles car	Ton-miles empty	Total ton-miles	Cars	Ton-miles load	Ton-miles car	Ton-miles empty	Total ton-miles		
1st South Faces: (Length of haul - 1.08 miles)																						
Loads	83	322		–	–	299	1,160	–	–	–	270	1,050	–	–	–	–	–	–	–	–	652	2,532
Cars.	83	–	177	–	–	299	–	640	–	–	270	–	580	–	–	–	–	–	–	–	652	1,397
Total . . .	–	–	–	–	499	–	–	–	–	1,800	–	–	–	–	1,630	–	–	–	–	–		3,929
Empties	20	–	–	43	–	560	–	–	1,200	–	59	–	–	126	–	39	–	–	83	–	678	1,452
Total ton-miles work.	–	–	–	–	542	–	–	–	–	3,000	–	–	–	–	1,756	–	–	–	–	83		5,381
2nd South Faces: (Length of haul - 1.48 miles)	No.8 locomotive makes only two trips to the shaft, one at the beginning and one at the end of the shift. In the meantime it works as flat-road motor on the 1st south faces (see data on secondary haulage, Table 2).																					
Loads						–	–	–	–	–	40	213	–	–	–	120	639	–	–	–	160	852
Cars.						–	–	–	–	–	40	–	117	–	–	120	–	352	–	–	160	469
Total						–	–	–	–	–	–	–	–	–	330	–	–	–	–	991		1,321
Empties						–	–	–	–	–	–	–	–	–	–	57	–	–	167	–	57	167
Total ton-miles work.						–	–	–	–	–	–	–	–	–	330	–	–	–	–	1,158		1,488
3rd South Faces: (Length of haul - 1.84 miles)																						
Loads				–	–	40	284	–	–	–	40	284	–	–	–	159	1,131	–	–	–	239	1,699
Cars.				–	–	40	–	145	–	–	40	–	145	–	–	159	–	579	–	–	239	869
Total . . .				–	–	–	–	–	–	429	–	–	–	–	429	–	–	–	–	1,710		2,568
Empties				–	–	23	–	–	84	–	–	–	–	–	–	191	–	–	695	–	214	799
Total ton-miles work.				–	–	–	–	–	–	513	–	–	–	–	429	–	–	–	–	2,405		3,367
Total loads hauled to shaft. . . .	83			–	–	399	–	–	–	–	350	–	–	–	–	279	–	–	–	–	1,051	
Total empties hauled from shaft	20			–	–	583	–	–	–	–	59	–	–	–	–	287	–	–	–	–	949	
Total ton-miles of work		–	–	–	542	–	–	–	–	3,513	–	–	–	–	2,515	–	–	–	–	3,646	10,216	

Table 2.- Ton-miles of work performed on secondary haulage No. 1 south faces and its butts, Locomotive 8, Nov. 1, 1928.

	Cars	Ton-miles load	Ton-miles car	Total load ton-miles	Ton-miles empties	Total ton-miles
No. 5 and 6 Butts:						
(Length of haul 0.39 miles)						
Load	59	82.60				
Car	59		45.55			
Total	59			128.16		
Empties.	59				45.55	
Total ton-miles work . . .						173.72
No. 7 Butt:						
(Length of haul 0.45 miles)						
Load	61	98.54				
Car	61		54.35			
Total	61			152.89		
Empties.	61				54.35	
Total ton-miles work . . .						207.24
No. 8 Butt:						
(Length of haul 0.56 miles)						
Load	73	146.75				
Car	73		80.94			
Total	73			227.70		
Empties.	73				80.94	
Total ton-miles work . . .						308.64
No. 9 Butt:						
(Length of haul 0.63 miles)						
Load	70	158.31				
Car	70		87.31			
Total	70			245.63		
Empties.	70				87.31	
Total ton-miles work . . .						332.95
No. 12 and 14 Butts:						
(Length of haul 0.95 miles)						
Load	75	255.78				
Car	75		141.07			
Total	75			396.86		
Empties.	75				141.07	
Total ton-miles work . . .						537.93

Table 2.- Ton-miles of work performed on secondary haulage No. 1 south faces and its butts, Locomotive 8, Nov. 1, 1928 (Continued).

	Cars	Ton-miles load	Ton-miles car	Total load ton-miles	Ton-miles empties	Total ton-miles
No. 1 South Faces:						
(Length of haul 1.02 miles)						
Load	82	300.26				
Car	82		165.60			
Total	82			465.87		
Empties.	82				165.60	
Total ton-miles work . . .						631.48
No. 0 South Faces:						
(Length of haul 1.25 miles)						
Load	84	376.95				
Car	84		207.90			
Total.	84			584.85		
Empties.	84				207.90	
Total ton-miles work . . .						792.75
Total loads hauled	504					
Total empties hauled	504					
Total ton-miles of work. .						2984.71

Averageweight of coal, 3.59 tons
Average weight of car, 1.98 tons
Total, 5.57 tons

As before mentioned, No. 8 locomotive makes only two trips to the shaft, one at the beginning and one at the end of each shift. In the meantime this locomotive works as the secondary haulage locomotive on the 1st south faces and accomplishes 2984.71 ton-miles, which with its 542 ton-miles on the main haulage totals 3516.71 ton-miles.

The table shows that No. 17 locomotive, which hauls an even trip during the shift, accomplishes 3,646 ton-miles of work, while No. 11 and No. 16 locomotives accomplished 3,513 and 2,515 ton-miles of work, respectively. The total ton-miles accomplished in the shift were 13,190.7 and the coal hauled to the shaft totaled 3,773 tons. This is the equivalent to an average haul per ton of 3.50 miles, and since the car capacity averaged 3.59 tons, the average haul of each 3.59 tons on main and secondary haulage was 0.97 miles.

On Nov. 7, 1927, the average haul from the face to the shaft was 9,177 feet. On June 30, 1926, the average haul from the face to the shaft was 8,665 feet, showing an increase of 512 feet during this period.

Mine Cars.- There are 740 mine cars of 100 cubic feet capacity at this plant with steel sides and ends and wooden bottoms, carrying 3.59 tons of coal as an average load. The axles are 3 inches in diameter and run in plain bearings.

The wheels are 18 inches in diameter, run loose on the axle, and are equipped with ratchet brakes. The wheel base is 32 inches.

During 1927, in 156 working days 173,147 cars of coal and 12,538 cars of refuse were dumped at the shaft, an average of 1,190 cars per working day or a turn around on 740 mine cars of 1.608.

Drainage pumps - type and capacity.- Excepting for the tunnels under the river this mine could be called dry. The mine water is gathered into two main sumps on the north side of the main east entries by twelve 2-inch and five 4-inch gathering pumps. From these sumps the water is pumped to the surface through the manway by two 10-inch pumps. At the present time it makes about 360 gallons of water per minute, the pumping generally being done on the night shift. The labor and material cost for drainage is 1.021 and .254 per cent, respectively, of the total cost of production.

Ventilation.- Ventilation is supplied by a 12 by 6 foot fan, belt-driven by a 200 hp. motor, exhausting 300,000 cubic feet per minute against a 2-inch water gauge. There is a good supply of air at each working face. Line brattices are used where necessary to conduct the ventilation to the working face, and doors constructed of lumber and canvas are used in preference to swing brattices. Permanent stoppings built of concrete are put in place as the entries advance. Overcasts built of concrete, reinforced with steel, are put in where required. A notable feature at this mine is that few doors are used on haulageways, overcasts being employed instead. The air courses are kept clean and free from fallen material.

The tunnels under the river and the shaft bottom are ventilated by a system independent of the main mine ventilation. A 6-foot disc fan placed at the head of the manway blows 32,000 cubic feet per minute against a 1-inch water gauge and is belt-driven by a 15 hp. motor which is used for this purpose. By this method the dust from the dump at the bottom of the shaft passes up the shaft, which is the outlet or return for this ventilating system. By this arrangement the shaft is kept free from ice in winter weather.

Power, source of supply, kind, and voltage.- Power is purchased in 2,300-volt A.C. units. At the mine side it is reduced to 250 volts D.C. by two motor generator sets of 300-kw. capacity each. The voltage used underground is 250 D.C. During September, 1928, 6.3 kw.-hrs. were consumed per ton of coal mined.

Tabulation of data.- Tables have been made up on classification of labor, and operating cost percentages.

The first, classification of labor, gives the percentage of men employed in the various classes of labor; such as contract labor, inside daymen, haulagemen, and outside day-labor.

The second gives the operating cost percentages under the following items:

Mining.- Cost of labor and supplies for loading, machine mining, company coal, mining machine repairs, miscellaneous mining expense, and supplies for these items.

Deadwork.- Cost of labor and supplies, for grading, cleaning falls, outside disposal of refuse, miscellaneous, and driving entries in faulted territory.

Timbering.- Cost of labor and supplies for timbering.

Ventilation.- Cost of operating the ventilating system and repairs to equipment.

Drainage.- Cost of operating the drainage system and repairs to equipment.

Haulage.- Cost of gathering and hauling coal, operating and maintaining mine roads or tracks, mine cars, and haulage system in general.

Tipple.- Cost of operation and repairs to equipment.

Power.- Cost of substation operation and repairs to equipment.

Purchased power.- Cost of power purchased from a public utility.

Repairs to structures.- Cost of repairs to the various structures at the plant.

Mine office expense.- Under mine office expense are included superintendence, mine foreman, engineering, mine office expenses, storeroom expenses, welfare work, first-aid and mine rescue, patrolmen and police, miscellaneous mine expense, machine shop expense, supplies and repairs to equipment.

Insurance, liability and compensation.- Cost of workmen's compensation insurance premiums.

Classification of Labor

Inside:	Per cent	Outside:	Per cent
Loaders	62.82	Labor-foreman	0.26
Cutters	4.72	Clerks	0.52
Contract labor	67.54	Garbageman	0.26
Inside Daymen:		Laborers	2.63
Mine foreman	0.26	Electricians	0.26
Assistant mine foreman	0.78	Substationmen	0.26
Firebosses	1.31	Blacksmiths	0.52
Roadmen	3.15	Car-repairers	0.52
Day laborers	5.24	Carpenters	0.26
Bratticemen	0.52	Tippleman	1.83
Wiremen	0.78	Machinist	0.26
Pumpers	0.78	Watchmen	0.78
Drillmen	0.52	Supply clerk	0.26
Machine repairmen	0.78	Total outside day labor	8.62
	14.12		

Haulage:	Per cent
Motor boss	0.26
Motormen	4.72
Motor brakemen	4.72
	9.70
Total inside labor . .	91.36

Operating Cost Percentages February to September, 1928, Inc.

Tonnage 428,667.50; 53,583 tons av. mo.

	Labor	Material	Total, per cent
Mining	63.000	1.254	64.254
Dead work.	1.193	.280	1.473
Timbering.	.734	1.083	1.817
Ventilation.	1.672	.448	2.120
Drainage	1.021	.254	1.275
Haulage.	10.110	3.722	13.832
Tipple	1.618	.302	1.920
Power.	.291	.032	.323
Purchased power. . . .	-	5.936	5.936
Repair to structures .	.058	.086	.144
Mine office expense. . .	4.797	.326	5.123
Insurance liability and compensation. .	1.783	-	1.783
Totals	86.277	13.723	100.000

Efficiency Data

Cutting machines, 2 men on crew Production per shift 240 to 250 tons

Tons produced per pound of explosive used	5.336 tons
Tons of coal produced per linear foot of timber used	1.765 tons
Tons of coal produced per prop used.	14.74 tons
Average number of cars gathered per gathering locomotive	71.17
Average number of cars gathered per storage-battery locomotive	63.6
Average number of cars gathered per reel locomotive.	76.57
Average number of cars handled to and from working face by gathering locomotive.	854

Average length of haul for gathering locomotive ranges from 500 to 1,500 feet.

Main haulage, total ton-miles shift (empty and loaded cars)	10,216
Secondary haulage, total ton-miles per shift (empty and loaded cars).	2,984.7
Total ton-miles per shift.	13,190.7
Tonnage of coal delivered to hoisting shaft per shift.	3,773
Average length of haul on main and secondary haulage.	0.97 miles
Number of times each car was loaded per shift.	1.608

Accidents.- During the year 1927, in 156 working days 622,242 tons of coal were produced, 384 men were employed, and there were 20 lost-time accidents. A total of 629 days was lost due to these accidents, which are attributed to the following causes: Falls of roof and coal 9, or 45 per cent; transportation 3, or 15 per cent; timbering 3, or 15 per cent, and miscellaneous causes 5, or 25 per cent. The following table shows tons produced per accident:

Tons produced per accident

Cause	No. of accidents	Total days lost	Tons per accident
Falls of roof and coal . .	9	313	69,138
Transportation	3	49	207,414
Timbering.	3	57	207,414
Miscellaneous.	5	210	124,448.4
Total.	20	629	31,112

Safety.- This mine is termed a gassy mine: therefore, electric safety cap lamps are used by the employees. The supervising officials use a flame safety lamp. At important points along the haulageway 250-volt electric lights are used, for which the power is taken from the trolley line.

Inspection.- Fire bosses are employed who examine each working place once before the men go on shift, and once while they are on shift, for any dangerous condition, and who report their findings in the daily report book.

The working places are also visited twice each day by the assistant mine foreman of the district, who examines for any dangerous condition and instructs the miner in his work.

Blasting.- Permissible explosives are used, fired electrically by a shotfirer, who examines the place thoroughly before firing a shot. Clay tamping is used, and the cuttings are scraped from under the mining before blasting.

Rock dust.- The mine has been rock-dusted several times from the face to the shaft, and rarely was a working place seen where rock-dust was more than 30 feet from the face. During 1927, 4,560 sacks of rock-dust were used. Barriers and shelves loaded with rock-dust have been placed at various points in the air courses. It is now the practice after dusting air courses to place platforms loaded with rock-dust at intervals of 100 feet. To minimize dust in the shaft, the loaded cars are sprinkled by an overhead device as they approach the hoisting shaft.

Recovering posts.- When posts are being recovered in making a fall in pillar work, they are pulled out by a locomotive with a piece of cable, thereby eliminating a chance of injury to workmen.

Trolley lines.- The trolley lines are well guarded at all important places by means of boards supported by anchors in the roof and forming an inverted trough.

Tracks.- The tracks are well kept, and all over the mine a clearance of 4 feet is provided on one side. Points of switches and frogs are blocked and guarded to prevent anyone from getting his feet caught in them. All switches are provided with parallel throw switch stands that lie close to the floor.

Manways.- Manways are provided so that the miner on leaving the butt entries does not have to travel on the haulageways.

Telephones.- Telephones are placed at important points on the main haulageways and at each alternate butt entry.

First aid.- A quantity of first-aid material, with stretcher and blankets, is kept at various points in the mine for immediate use in case of an accident to an employee.

Refuge chamber.- At each pair of butt entries in all new development work, a refuge chamber as shown in Figure 17 has been constructed. This chamber is kept clean and well posted and has a concrete wall built near the mouth with a door ready to be put in place if in case of a fire or explosion it is necessary for men to barricade themselves.

Fire extinguishers.- An 80-gallon chemical fire extinguisher, mounted on a truck with 300 feet of hose ready to be used in case of fire, is kept in the motor barn. At each butt entry and at important places about the mine, 2 1/2-gallon chemical fire extinguishers are maintained and kept ready for use.

Motor barn.- A motor barn with the stalls concreted has been built near the main east entries. Figure 18 is a plan of the barn, which is equipped with apparatus for charging storage-battery locomotives, and with a shop and motor pit for repair work.

SUMMARY

The features at this mine that are especially notable are as follows:

1. There seems to be a place for everything, and everything in place. The mechanical equipment is modern and is kept in good condition.

2. The mining method, the long break lines, and the method of roof control are giving good results. The practice of removing the entry stumps and butt entry chain pillars by extending the room through these pillars fits in well with the maintenance of long break lines.

3. The haulage is mechanical throughout; the cars are delivered to and from the working faces by locomotives. Tracks are kept clean and in good condition.

4. While approximately 360 gallons of water per minute are being pumped, in general, the mine may be called dry. A good portion of this water is seepage from the river.

5. Roof support is supplied where necessary on the haulageways. Steel I-beams are used for crossbars. The method of posting in rooms and pillars is adequate for the needs of the roof; however, some improvement could be made by applying a good cap piece, 18 inches long, 4 inches thick and wide enough to cover the post. The practice now being followed in using T-rails instead of wooden crossbars in rooms and pillars should give good results.

6. Ventilation is good at all places. Overcasts and stoppings are well built and maintained; line brattices are carried to the face where necessary.

7. Supervision at this mine is good; each working place is visited at least three times during the shift by a supervising official.

UNDERGROUND MANAGEMENT AND PAY SYSTEM USED

All underground employees are under the direct control of the mine foremen and their work is supervised by assistant foremen assigned to different districts. The foreman and his assistants are paid on a day or contract rate, and no bonus is paid to any employee. The machinemen and miners only are paid on a tonnage rate. A higher tonnage rate is paid for work in narrow places to miners and machine men, but not as a bonus. No particular task to constitute a shift's work is assigned any of the underground employees.

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